jc571 U.S. PTO
06/14/99

jc511 U.S. PTO
09/332420
06/14/99

A

PATENT APPLICATION TRANSMITTAL LETTER

ATTORNEY'S DOCKET NO.
AD-2

TO THE COMMISSIONER OF PATENTS AND TRADEMARKS:

Transmitted herewith for filing is the patent application of David Edgar Hauber
(Inventor)

for REINFORCED THERMOPLASTIC PIPE MANUFACTURE
(Title of invention)

Enclosed are:

[X] two (2) sheets of drawing.

[ ] an assignment of the invention to

CLAIMS AS FILED

FOR	NUMBER FILED	NUMBER EXTRA	RATE	BASIC FEE $380
TOTAL CLAIMS	34 − 20 =	-14-	x 9.00	126
INDEPENDENT CLAIMS	5 − 3 =	-2-	x 39.00	78
ADDITIONAL FEE FOR USE OF MULTIPLE DEPENDENT CLAIM(S) (once per application)			$	
		TOTAL FILING FEE →		$584.00
		FEE FOR RECORDING ASSIGNMENT		
			TOTAL	$584.00

[X] Original

[ ] Continuation-In-Part of Serial No. ______, Filed ______.
(Docket No. ______)

[X] Small entity status

[x] A check in the amount of $ 584.00 to cover the filing fee is enclosed.

June 11, 1999
Date

J.F. McDevitt
Attorney of Record
Reg. No. 19,140

After recording, mail

John F. McDevitt
2255 Par Lane, Apt. 626
Willoughby Hills, Ohio 44094

A D - -

AD-2

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

[X] In re Application of :

David Edgar Hauber

Serial No. : Group No.

Filed: : Examiner:

FOR: REINFORCED THERMOPLASTIC PIPE MANUFACTURE :

Commissioner of Patents and Trademarks
Washington, D.C. 20231

SUBMISSION OF VERIFIED STATEMENT(S) TO ESTABLISH SMALL ENTITY STATUS

The attached statement is being submitted to establish small entity status in this

[X] application

[ ] patent

by the:

a. [X] independent inventor(s) 37 CFR 1.9(c) and 1.27(b)

b. [ ] non-inventor supporting claim by author 37 CFR 1.9(c) and 1.27(b)

c. [ ] small business concern 37 CFR 1.9(d) and 1.27(c)

d. [ ] non-profit organization 37 CFR 1.9(e) and 1.27(d)

Reg. No. 19,140

Tel. No. (216) 585-0919

J F McDevitt
Signature of Attorney

John F. McDevitt
2255 Par Lane #626
Willoughby Hills, OH 44094

CERTIFICATE OF MAILING (37 CFR 1.8a)

I hereby certify that this paper (along with any paper referred to as being attached or enclosed) is being deposited with the United States Postal Service on the date shown below with sufficient postage as first class mail in an envelope addressed to the Commissioner of Patents and Trademarks, Washington, D.C. 20231.

Date June 11, 1999

J F McDevitt

PTO/SB/10 (1-99)
Approved for use through 09/30/2000. OMB 0651-0031
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

STATEMENT CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) & 1.27(c))--SMALL BUSINESS CONCERN

Docket Number (Optional) AD-2

Applicant, Patentee, or Identifier: David Edgar Hauber
Application or Patent No.:
Filed or Issued:
Title: REINFORCED THERMOPLASTIC PIPE MANUFACTURE

I hereby state that I am
☒ the owner of the small business concern identified below:
☐ an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF SMALL BUSINESS CONCERN ADC Acquisition Company

ADDRESS OF SMALL BUSINESS CONCERN 407 Front Street
Schenectady, New York 12305

I hereby state that the above identified small business concern qualifies as a small business concern as defined in 13 CFR Part 121 for purposes of paying reduced fees to the United States Patent and Trademark Office. Questions related to size standards for a small business concern may be directed to: Small Business Administration, Size Standards Staff, 409 Third Street, SW, Washington, DC 20416.

I hereby state that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention described in:

☒ the specification filed herewith with title as listed above.
☐ the application identified above.
☐ the patent identified above.

If the rights held by the above identified small business concern are not exclusive, each individual, concern, or organization having rights in the invention must file separate statements as to their status as small entities, and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person made the invention, or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d), or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern, or organization having any rights in the invention is listed below:
☐ no such person, concern, or organization exists.
X ☒ each such person, concern, or organization is listed below.

David Edgar Hauber

Separate statements are required from each named person, concern or organization having rights to the invention stating their status as small entities. (37 CFR 1.27)

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

NAME OF PERSON SIGNING James A. Mondo

TITLE OF PERSON IF OTHER THAN OWNER PRESIDENT

ADDRESS OF PERSON SIGNING 17 VALENCIA LANE, CLIFTON PARK, NY 12065

SIGNATURE James A. Mondo DATE May 28, 1999

Attorney Docket
AD-2

Applicant David Edgar Hauber

Serial No. ______

Filed: ______

For: REINFORCED THERMOPLASTIC PIPE MANUFACTURE

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) and 1.27(b))-INDEPENDENT INVENTOR

As a below named inventor, I hereby declare that I qualify as an independent inventor as defined in 37 CFR 1.9(f) for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code, to the Patent and Trademark Office with regard to the invention entitled REINFORCED THERMOPLASTIC PIPE MANUFACTURE described in

[XX] the specification filed herewith.

[ ] application serial no. 0 / ______ filed ______.

[ ] patent no. ______, issued ______.

I have not assigned, granted, conveyed or licensed and am under no obligation under contract or law to assign, grant, convey or license, any rights in the invention to any person who could not be classified as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, or to any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit corporation under 37 CFR 1.9(e).

Each person, concern or organization to which I have assigned, granted, conveyed, or licensed or am under an obligation under contract or law to assign, grant, convey, or license any rights in the invention is listed below:

[ ] no such person, concern, or organization

[XX] person, concerns or organizations listed below*

FULL NAME ADC Acquisition Company

ADDRESS 407 Front Street
Schenectady, New York 12305

[ ] Individual [XX] Small Business Concern [ ] Nonprofit Organization

FULL NAME ADC AQUISITION COMPANY
ADDRESS 407 FRONT STREET
SCHENECTADY, NY 12305

[ ] Individual [X] Small Business Concern [ ] Nonprofit Organization

FULL NAME ____________________
ADDRESS ____________________

[ ] Individual [ ] Small Business Concern [ ] Nonprofit Organization

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b)).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

David Edgar Hauber
Name of inventor

David Edgar Hauber
Signature of Inventor

June 4, 1999
Date

REINFORCED THERMOPLASTIC PIPE MANUFACTURE

BACKGROUND OF THE INVENTION

This invention relates generally to the manufacture of fiber reinforced thermoplastic pipe lengths and more particularly to a novel continuous processing means for the manufacture of these articles.

The fiber reinforcement of pipe members formed with both thermoset and thermoplastic organic polymers has already gained wide commercial acceptance attributable to affording high strength and stiffness per unit weight when compared to pipe fabrication with the conventional materials previously used for transporting various fluids such as concrete, steel and the like. A variety of fabrication procedures are also well known to produce the composite pipe member with continuous fiber filaments which are commonly applied to the outer pipe surface. In one example, a tension winding process is commercially employed whereby a thermoplastic pipe or coupler member is rotated on a mandrel while the reinforcing fiber is being applied under heat and tension. The fiber tension during winding or wrapping around the underlying thermoplastic member provides a compaction force therebetween to secure thermal bonding of the fibers after the heating has melted or softened the outer surface of the thermoplastic material. This process has been found limited to relatively high fiber angles with respect to the longitudinal axis of the

pipe or coupler member, typically greater than 15 degrees because the radial component of the fiber tension provides this compaction force. While tension winding can be augmented with a use of compaction roller means to increase the radial compaction force, the resulting low fiber angles produce undesirable fiber build-up at the mandrel ends since the continuous fibers being applied cannot be cut for a restart of the filament winding process. A further need to apply relatively high pressure as well as provide mandrel rotation during said tension winding process requires robust and expensive mandrels together with significant mandrel handling labor. In a different manufacturing process for the production of reinforced plastic pipe members, continuous glass fibers in a thermoset epoxy matrix are employed. Still other manufacturers produce a reinforced thermoplastic pipe construction having the thermoplastic pipe member as an innerlayer which is surrounded by various outerlayers of the reinforcement material. For example, one such manufacturer surrounds the thermoplastic liner with a fiberglass layer in an epoxy resin matrix and provides an exterior protective layer thereover of a still different fiber material which is again contained in an organic polymer matrix. Using thermoset polymers in the reinforcement of a thermoplastic pipe member frequently creates additional manufacturing problems. The curing required of these polymers

occasions contamination as well as time delay and these materials are not recyclable.

Another complex reinforced thermoplastic pipe construction is disclosed in United States Patent No. 4,850,395. As therein described, a core member of thermoplastic material is wound with an inner aramid fiber layer while being covered with still additional tape and metal outer layers. Such end product is understandably found to be both cumbersome and expensive to manufacture. In United States Patent No. 4,469,138 there is disclosed polypropylene pipe lengths reinforced by simply mixing discrete carbon fibers in the starting polymer composition. The resulting product lacks the mechanical strength afforded with continuous fiber reinforcement as well as lacks the ability to orient continuous fibers in a predetermined spatial direction for maximum effectiveness in withstanding applied stress when the pipe member is in service. In the latter regard, such controlled directional orientation of the continuous fiber component in the reinforced thermoplastic pipe member enables the fiber placement to be fixed for such maximum effectiveness since the fiber materials being employed are generally stronger than the thermoplastic polymers forming the pipe member. The fiber reinforced end product is thereby only as strong as the spatial direction of the applied fibers with respect to the direction of the external stress when applied to said reinforced pipe member. Thus, when the fiber reinforced pipe member is

stressed by internal fluid pressures in the direction of the fiber placement, the applied load is withstood primarily by the included fibers and the strength of said pipe member is at maximum value. Conversely, when the composite member is stressed in a perpendicular direction to the fiber direction, the applied force must necessarily be resisted primarily by the polymer pipe member so that pipe strength is at a minimum. From such consideration and a further analysis of the expected stress during pipe service employing recognized shell theory calculations, it has been determined that certain installations of the present fiber reinforced thermoplastic pipe members dictate a fiber orientation in the hoop direction whereas dissimilar pipe installations require the fiber direction to be oriented at lesser angles with respect to the longitudinal axis of the reinforced pipe member.

A still more arduous method for reinforcement of a thermoplastic pipe member is disclosed in United States Patent No. 4,347,090 which employs a fabric sleeve applied about the pipe member for this purpose. The method requires an inner liner to be filled with liquid which is then heated causing said liner to expand as well as become partially molten for thermal bonding to an overlying glass fabric layer. An outermost layer comprising a thermoset resin impregnated glass cloth completes the reinforcement. Such final product and

its method of fabrication are understandably both complex and expensive.

In United States Patent No. 4,770,442 there is also disclosed a rather complex electrofusion type coupler being employed to join synthetic resin pipe lengths together. Said coupler member employs a cylindrical thermoplastic sleeve which includes a metal heating wire being disposed adjacent the inside surface while being reinforced on the outside surface with a winding or covering formed with a material composition exhibiting a lower thermal expansion than that of the thermoplastic sleeve material. Such reinforcement is said to limit any outward radial expansion of the composite sleeve during subsequent thermal bonding of said member to the pipe lengths being joined together by this means.

It is an important object of the present invention, therefore, to provide a more effective means for the fiber reinforcement of a thermoplastic pipe member in a continuous manner.

It is another important object of the present invention to provide a novel fiber reinforced thermoplastic pipe member having the fiber placement physically incorporated therein so as to better resist the applied stress encountered during use in a significantly improved manner.

Still another important object of the present invention is to provide a novel method for continuous fabrication of a fiber reinforced thermoplastic pipe member.

A still further important object of the present invention is to provide novel apparatus means for the continuous fabrication of a fiber reinforced thermoplastic pipe member.

These and still further objects of the present invention will become more apparent upon considering the following more detailed description of the present invention.

SUMMARY OF THE INVENTION

It has been discovered, surprisingly, that fiber reinforcement of a thermoplastic pipe length can be carried out more effectively in a continuous manner by reversing the customary relative rotation between the fiber when applied and the pipe member. More particularly, the processing procedure of the present invention continuously moves the pipe length in a linear direction without rotation while wrapping a plurality of continuous juxtapositioned reinforcement fibers formed with a material composition selected from the group consisting of ceramics, metals, carbon and organic polymers in an unbonded condition about the outer surface of said moving pipe member in a predetermined spatial direction and thereafter heating the fiber wrapped pipe length sufficiently to cause thermal bonding between the reinforcement fibers and the pipe outer surface while said fiber wrapped pipe length continues to move in the same linear direction. To impart increased mechanical strength for said fiber reinforcement requires that the fiber placement be carried out with the fibers being oriented in a

particular spatial direction depending upon end use of the wrapped pipe length as previously pointed out herein. In accordance therewith, the fibers can be wrapped in a hoop direction about the pipe length as well as wrapped at lesser or interim angles with respect to the longitudinal axis of said pipe length. Additionally, multiple wraps of the reinforcement fibers can be applied continuously in accordance with the present processing procedure to include one or more overwraps being applied to serve as a protective covering from exposure of the final product to environmental or mechanical damage. Likewise, having the individual fiber wraps applied continuously in different spatial directions is contemplated in accordance with the present processing procedure and with the individual wraps all being bonded to the underlying thermoplastic pipe member after placement with a single heating step. The present processing procedure can similarly be carried out with multiple pipe lengths that have been joined together at the pipe ends in an in-line configuration before continuous fiber placement by employing conventional means such as butt-welding, adhesive bonding and the like as well as possibly being joined together with only a physical abutment existing therebetween. Suitable thermoplastic organic polymer materials forming the pipe member in the present composition construction include but are not limited to polyethylene such as high density polyethylene and medium density polyethylene, polypropylene, polyphenylene sulfide,

polyetherketoneketone, polyamide, polyamideimide, and polvinylidene difloride. Similarly, a wide variety of materials are found suitable as the fiber reinforcement in the present processing procedure to again include but not be limited to ceramics, metals, carbon, aramid and other polymer fibers having softening temperatures above that of the pipe service temperature in use and glass compositions such as E type and S type glass.

Basically, the present thermal bonding of continuous fibers after having been wrapped in an unbonded condition about the outer periphery of the thermoplastic pipe length or lengths involves an operative cooperation between the applied fibers and the outer surface of said pipe member. A softening or melting action takes place during the thermal bonding step between the outer surface of the thermoplastic pipe member and any thermoplastic polymer materials serving as the matrix composition in selected preformed tape embodiments having the continuous reinforcement fibers bonded therein. In this manner, the applied fibers become physically joined to the pipe member with softened or melted thermoplastic polymer when the fiber wrapped pipe member is heated in the present method such as occurs when melting said outer pipe surface. The present heating step also produces a significant radial expansion of the pipe member upon heating which further promotes the physical adherence of the applied fibers to the outer pipe surface. In so doing, a radial compaction or compressive force is

generated in the joined components with the maximum benefit being imparted by having the coefficient of thermal expansion for the selected fiber material being lower than that for the thermoplastic pipe polymer. The herein defined fiber reinforcement method understandably enables a wide variety of fiber materials to be selected as previously pointed out. Thus, a reinforcement fiber material can be selected from the aforementioned class of suitable materials so long as it is mechanically stiffer than the selected thermoplastic pipe polymer and has a glass transition or melting temperature higher than the service temperature of the thermoplastic pipe member during use. Selected polymer fibers can understandably include continuous bare filaments and comingled continuous fibers which can be wetted by polymer melt flow in the above mentioned compaction zone during heating. For selection of a suitable preformed continuous fiber material or prepreg tape having a matrix formed with a thermoplastic polymer, said matrix polymer is desirably chosen to have a softening or melt temperature equal to or lower than the softening temperature of the selected pipe polymer.

Any suitable heating source can be used in the present method to continuously bond the applied fiber reinforcement to the outer thermoplastic pipe surface. Contemplated heat sources include but are not limited to inert gases, oxidizing gases and reducing gases, including mixtures thereof, infrared heating sources, such as infrared panels and focused

infrared means, conduction heating sources such as heated rollers, belts and shoe devices, electrical resistance heating sources, laser heating sources, microwave heating sources, RF heating sources, plasma heating sources and ultrasonic heating sources. An external flame heat source provides economical heating with high energy densities and with the gas burner or burners being suitably designed so as to surround the outer circumference of the fiber wrapped thermoplastic pipe member. Understandably, the employment of a continuous heating step in the present method can further advise auxiliary equipment means to be operatively associated therewith in the event of process interruptions such as fast responsive heating devices or cooling means averting meltdown of the materials being processed. It is also contemplated that the present method of thermally bonding the applied reinforcement fibers continuously to the outer surface of said thermoplastic pipe member can be modified in a still further manner. Accordingly, roller members rotatably mounted so as to press against the already heated fiber wrapped thermoplastic pipe member can be employed to help generate the aforementioned compaction force found beneficial in carrying out the present method. Such compaction rollers can be cooled, heated or remain at ambient temperatures in the present method depending upon the process requirements being carried out as well as the physical characteristics desired in the final product.

As above indicated, the present continuous method necessarily further includes provision being made for both start-up as well as termination and possible process interruption. Satisfactory start-up of the present processing procedure can be conducted in various ways to include starting with a single thermoplastic pipe length or multiple pipe lengths and feeding these members with continuous linear motion at a relative constant velocity to suitable fiber winding means. A continuous thermoplastic pipe length can be suitably provided employing conventional extruder means while the feeding of discrete pipe lengths to the operatively associated fiber winding means can preliminarily involve having the discrete pipe lengths simply butted together physically in an in-line configuration as well as having the respective pipe ends fused or welded to each other. Conventional means can be employed for continuous transport of the thermoplastic pipe member during processing in said manner including known moving belt drive mechanisms and motor driven rollers. Suitable start-up would also optionally include having the initial continuous fiber being physically secured to the outer surface of the first moving thermoplastic pipe member being processed with conventional clamping or adhesive bonding means. Following a continuous thermal bonding of the applied reinforcement fibers in the manner previously described, the present method can be terminated with conventional cut-off means being employed to suspend

any further fiber placement. Satisfactory cut-off means can utilize a moving cutter device traveling in the same linear direction as the moving pipe member or members and to include a cutter severing the pipe along with the applied fiber reinforcement.

Novel apparatus means are employed to provide continuous fabrication of the present fiber reinforced thermoplastic pipe member. Basically, the present apparatus employs pipe feeding means which continuously transports the pipe length in a linear travel direction for operative association with rotating fiber supply means, fiber supply means which rotate about the circumference of said moving pipe length to continuously apply a plurality of juxtapositioned reinforced fiber wraps in a predetermined spatial direction on the outer surface of said moving pipe length, and heating means which causes thermal bonding to be continuously formed between the applied reinforcement fiber wraps and the outer surface of the moving pipe length. Said apparatus can further include a plurality of individual fiber supply means to serve various purposes such as applying successive fiber wraps at different fiber placement angles, reversing the application direction of successive fiber wraps, and applying overwraps of continuous fiber or tape material to serve as a protective covering against environmental or mechanical damage to the final product. A satisfactory embodiment for said individual fiber supply means can be a conventional cylindrical winder mechanism operatively associated

with a rotary fiber or tape spool. The pipe feeding means in the present apparatus can also be of conventional construction, as previously pointed out, to include known moving belt drive mechanisms as well as motor driven rollers and the like. While a further previously mentioned wide variety of heating sources can be employed in the present apparatus for continuous thermal bonding of the applied fiber or tape wraps, it remains advisable for the selected heat source to uniformly provide heat about the entire circumference of the fiber wrapped pipe length in doing so. In the apparatus embodiments to be more fully described hereinafter, the particular heating means being employed consists of a stationary cylindrically shaped heater that surrounds the entire circumference of the fiber wrapped pipe member and which is equipped with appropriately disposed internal gas burners. Moving cutter means are also employed in the illustrated apparatus embodiments for the purpose of severing the moving fiber wrapped pipe member into one or more suitable lengths upon completion of the herein described thermal bonding procedure. The entire apparatus in said illustrated embodiments is further operated automatically with known robotic control means employing a conventional velocity servomechanism system.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic view depicting typical processing equipment which can be employed

to continuously fabricate the fiber reinforced thermoplastic pipe member of the present invention.

Figure 2 schematically depicts representative automatic control means for the Figure 1 processing equipment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, Figure 1 is a schematic drawing depicting a representative processing apparatus which can be employed to continuously fabricate the present fiber reinforced thermoplastic pipe member. The depicted equipment means further illustrates the individual process steps being employed for said continuous fabrication according to the present invention. Said combined equipment and process flow chart 10 first utilizes a conventional tractor type feed mechanism 12 to continuously transport the supplied bare thermoplastic pipe length 14 in a horizontal linear direction at constant speed through the depicted apparatus 16. The bare pipe member 14 proceeds in said manner to a first cylindrical winder mechanism 18 which employs a motor driven rotating drum member 20 surrounding the pipe circumference to continuously wrap a first ply of the reinforcement fiber 22 about the outer surface of the moving pipe length. The reinforcement fiber comprises a plurality of the selected continuous length juxtapositioned fibers being supplied from a rotary spool 24 operatively associated with said winder mechanism and which feeds the supplied fiber material at a relatively constant rotational speed.

As further shown in the present drawing, said first wrap or ply of the fiber reinforcement has been applied in an unbonded condition at a predetermined spatial angle with respect to the longitudinal axis of the moving pipe length in response to a counterclockwise rotation of drum member 20. While not specifically identified in the present drawing, the particular reinforcement fiber material 22 being applied in the illustrated embodiment consists of continuous length glass filaments embedded in a thermoplastic polymer matrix but still other commercially available prepreg or preformed reinforcement tapes of similar construction are deemed equally suitable for processing in the illustrated apparatus.

The initially fiber wrapped moving pipe length 26 is next transported to a second cylindrical winder mechanism 28 with the same type rotating drum member 30 and rotary spool 32 previously employed for application of a second ply of the same fiber reinforcement 34. In doing so, it can be seen that said fiber reinforcement is now aligned in an unbonded condition at a different predetermined placement angle with respect to the longitudinal axis of the moving pipe length than previously employed and with said placement of the second ply being in response to a clockwise rotation of drum member 30. The now two-ply fiber wrapped pipe length 36 is next further transported to a third cylindrical winder mechanism 38 again having the same rotating drum member 40 and rotary spool 42

where a final ply 44 of protective overwrap 46 such as a thermoplastic film tape is applied over the moving fiber reinforced pipe length to protect the fibers from handling and/or environmental degradation. As can again be noted from the present drawing, said protective overwrap has been applied at a predetermined reverse spatial angle from that employed in the preceding fiber wrap and with drum member 40 rotating again in a counterclockwise direction. It becomes possible in such manner to help improve the overall mechanical strength of the applied fiber reinforcement while still further enabling the protective overwrap to add to the compaction force generated when the fiber reinforcement is thereafter thermally bonded to the pipe member. Said thermal bonding is carried out continuously with the now protected fiber wrapped pipe member 48 being transported to a stationary heating means 50 which again encloses the pipe member while being spaced apart therefrom and which consists of a hollow cylinder provided with suitable internal heating elements of the type hereinbefore disclosed. Passage of the pipe member in the same linear direction at constant speed through the length of said heated chamber in the present apparatus embodiment causes thermal bonding of all wraps on the pipe circumference to become secure to the underlying outer pipe surface and with the individual fiber wraps retaining the applied spatial direction. A movable cut-off mechanism 52 mechanically severs the now completed fiber

reinforced thermoplastic pipe member 54 into suitable lengths without interrupting continuous movement of the remaining pipe construction through the illustrated apparatus. Such cut-off operation can be carried out with various known saw or knife devices such as already employed in existing plastic pipe extrusion apparatus. The illustrated traveling cutter could use a knife means including a circular knife if only the reinforced fiber is to be severed whereas a saw device is deemed preferable if an entire fiber reinforced pipe length is desired to be removed from the remaining pipe construction. Additionally, it is contemplated that said traveling cutter mechanism could still further include router, planar, or chamfer means and the like to provide a customized profile at one or more cut-ends of the severed pipe length if desired for a particular end use application.

In Figure 2 there is shown schematically in block diagram form a representative automated control system for the Figure 1 processing apparatus. Basically, said control system 60 includes a conventional velocity type servomechanism to regulate the pipe movement and fiber wrapping operations conducted in said apparatus as dictated by an operator activated interface. Identification numerals employed in the present drawing further include the same numerals previously used in the Figure 1 apparatus description for the purpose of herein denoting the operative association between controlled components of said apparatus and

components of the presently illustrated control means. The overall control system 60 herein depicted is of the known master-slave type whereby the tractor feed component 12 operates as the master control component with all cylindrical wrapping components 18, 28 and 38 being slaved thereto. In accordance therewith the velocity or speed ratio between the master and slave servo control means 62 is determined by main control component 64 in the illustrated control system as regulated by settings in the operator interface component 66. Heater control component 68 in the illustrated control system automatically handles all heating requirements while also signaling the main control (64) and operator interface (66) components in the illustrated control system of both process operating conditions and any fault conditions discovered during apparatus operation. Cut-off control 70, if used, is actuated by main control 64 with a setting established through the operator interface component 66. Remaining power control component 72 in the illustrated control system is operated in the conventional manner with settings controlling power input from a customary power supply (not shown) to the illustrated apparatus.

It will be apparent from the foregoing description that a broadly useful and novel means to continuously fabricate a fiber reinforced thermoplastic pipe member in a more effective manner has been provided. It is contemplated that already known modifications can be made in the fiber wrapped

pipe member produced in such manner than herein specifically recited as well as process end apparatus modifications being made in carrying out such continuous fabrication procedure. Consequently, it is intended to cover all variation in the disclosed fabrication procedure which may be devised by persons skilled in the art as falling within the true spirit and scope of the herein claimed invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A fiber reinforced pipe length formed of a solid thermoplastic organic polymer member with inner and outer surfaces having a plurality of continuous juxtapositioned reinforcement fibers formed with a material composition selected from the group consisting of ceramics, metals, carbon and organic polymers which are thermally bonded to the outer surface of said pipe length in a predetermined spatial direction with respect thereto, said reinforcement fibers having been continuously wrapped about the outer surface of said pipe length in an unbonded condition while said pipe length is continuously moving in a linear direction with respect thereto and followed by sufficient heating of the fiber wrapped pipe length to cause thermal bonding therebetween while the pipe length continues movement in the same linear direction.

2. The fiber reinforced pipe length of claim 1 having multiple wraps of the reinforcement fibers.

3. The fiber reinforced pipe length of claim 1 wherein the reinforcement fibers are wrapped in the hoop direction.

4. The fiber reinforced pipe length of claim 1 wherein the reinforcement fibers are wrapped at an angle with respect to the longitudinal axis of the pipe length.

5. The fiber reinforced pipe length of claim 1 wherein the pipe length has a cylindrical configuration.

6. The fiber reinforced pipe length of claim 2 wherein the individual fiber wraps are aligned in different spatial directions.

7. A plurality of identical fiber reinforced pipe lengths joined together at the ends and each formed of the same solid thermoplastic organic polymer with inner and outer surfaces, said joined pipe lengths having a plurality of continuous juxtapositioned reinforcement fibers formed with a material composition selected from the group consisting of ceramics, metals, carbon and organic polymers which are thermally bonded to the outer surface of each joined pipe length in a predetermined spatial direction with respect thereto, said reinforcement fibers having been continuously wrapped about the outer surface of said joined pipe lengths in an unbonded condition while said joined pipe lengths are continuously moving together in a linear direction with respect thereto and followed by sufficient heating of the fiber wrapped joined pipe lengths to cause thermal bonding

therebetween while the joined pipe lengths continue movement in the same linear direction.

8. The fiber reinforced pipe lengths of claim 7 having multiple wraps of the reinforcement fibers.

9. The fiber reinforced pipe lengths of claim 8 wherein the individual fiber wraps are aligned in different spatial directions

10. The fiber reinforced pipe lengths of claim 7 wherein the reinforcement fibers are wrapped at an angle with respect to the longitudinal axis of the joined pipe lengths.

11. A method for reinforcement of a pipe length with inner and outer surfaces and formed with a solid thermoplastic organic polymer which comprises:

(a) continuously moving the pipe length in a linear direction,

(b) wrapping a plurality of continuous juxtapositioned reinforcement fibers formed with a material composition selected from the group consisting of ceramics, metals, carbon and organic polymers while in an unbonded condition about the outer surface of said moving pipe length in a predetermined spatial direction, and

(c) heating the fiber wrapped pipe length sufficiently to cause thermal bonding between the

reinforcement fibers and the pipe length while said pipe length continues to move in the same linear direction.

12. The method of claim 11 wherein the thermal bonding includes radial expansion of the moving pipe length.

13. The method of claim 11 wherein the thermal bonding includes melting of the pipe outer surface.

14. The method of claim 11 wherein the reinforcement fibers are provided in a matrix formed with a solid thermoplastic organic polymer.

15. The method of claim 14 wherein the thermal bonding includes melting of the fiber matrix.

16. The method of claim 11 wherein the thermal bonding includes radial expansion of the moving pipe length and melting of the pipe outer surface.

17. The method of claim 14 wherein the thermal bonding includes radial expansion of the moving pipe length while being accompanied by melting of the outer pipe surface as well as melting of the reinforcement fiber matrix.

18. A method for reinforcement of a plurality of identical pipe lengths joined together at the ends and each formed of the same solid thermoplastic polymer with inner and outer surfaces which comprise:

(a) continuously moving the joined pipe lengths in a linear direction,

(b) wrapping a plurality of continuous juxtapositioned reinforcement fibers formed with a material composition selected from the group consisting of ceramics, metals, carbon and organic polymers while in an unbonded condition about the outer surface of each moving joined pipe length in a predetermined spatial direction, and

(c) heating the fiber wrapped pipe lengths sufficiently to cause thermal bonding between the reinforcement fibers and the pipe lengths while said joined pipe lengths continue to move in the same linear direction.

19. The method of claim 18 wherein the thermal bonding includes radial expansion of the moving pipe lengths.

20. The method of claim 18 wherein the thermal bonding includes melting of the pipe outer surfaces.

21. The method of claim 18 wherein the reinforcement fibers are provided in a matrix formed with a solid thermoplastic organic polymer.

22. The method of claim 21 wherein the thermal bonding includes melting of the fiber matrix.

23. The method of claim 18 wherein the thermal bonding includes radial expansion of the moving pipe lengths and melting of the outer pipe surfaces.

24. The method of claim 21 wherein the thermal bonding includes radial expansion of the moving pipe lengths while being accompanied by melting of the outer pipe surfaces as well as melting of the reinforcement fiber matrix.

25. An apparatus for reinforcement of a pipe length with inner and outer surfaces and formed with a solid thermoplastic organic polymer which includes:

(a) pipe feeding means which continuously transports the pipe length in a linear travel direction for operative association with rotating fiber supply means,

(b) fiber supply means which rotate about the circumference of said moving pipe length to continuously apply a plurality of juxtapositioned reinforcement fiber wraps in a predetermined spatial direction on the outer surface of said moving pipe length, and

(c) heating means which causes thermal bonding to be continuously formed between the applied reinforcement fiber wraps and the outer surface of the moving pipe length.

26. The apparatus of claim 25 which includes a plurality of the fiber supply means.

27. The apparatus of claim 25 which includes mechanical cut-off means operatively associated with the fiber supply means to terminate reinforcement fiber application.

28. The apparatus of claim 25 wherein the fiber supply means comprises a cylindrical winder mechanism operatively associated with a rotary fiber spool.

29. The apparatus of claim 28 wherein the fiber spool provides the juxtapositioned reinforcement fibers in a matrix formed with a solid thermoplastic organic polymer.

30. The apparatus of claim 25 wherein the pipe feeding means provides continuous linear motion at a constant velocity.

31. The apparatus of claim 30 wherein the pipe feeding means is carried out with a moving belt drive mechanism.

32. The apparatus of claim 26 wherein the individual fiber wraps are aligned in different spatial directions.

33. The apparatus of claim 25 wherein the heating means employs a cylindrical heater surrounding the fiber wrapped pipe length.

34. The apparatus of claim 25 wherein the pipe feeding means continuously supplies a plurality of discrete pipe lengths joined together at the ends.

REINFORCED THERMOPLASTIC PIPE MANUFACTURE

ABSTRACT OF THE DISCLOSURE

A fiber reinforced thermoplastic pipe member is obtained by a novel continuous process in which the reinforcement fibers are wrapped about the outer pipe surface in an unbonded condition while the pipe member continuously moves in a linear direction and which is followed by sufficient heating of the moving fiber wrapped pipe member to cause thermal bonding between the applied fibers and the pipe member. Automated apparatus for carrying out the continuous process is also disclosed.

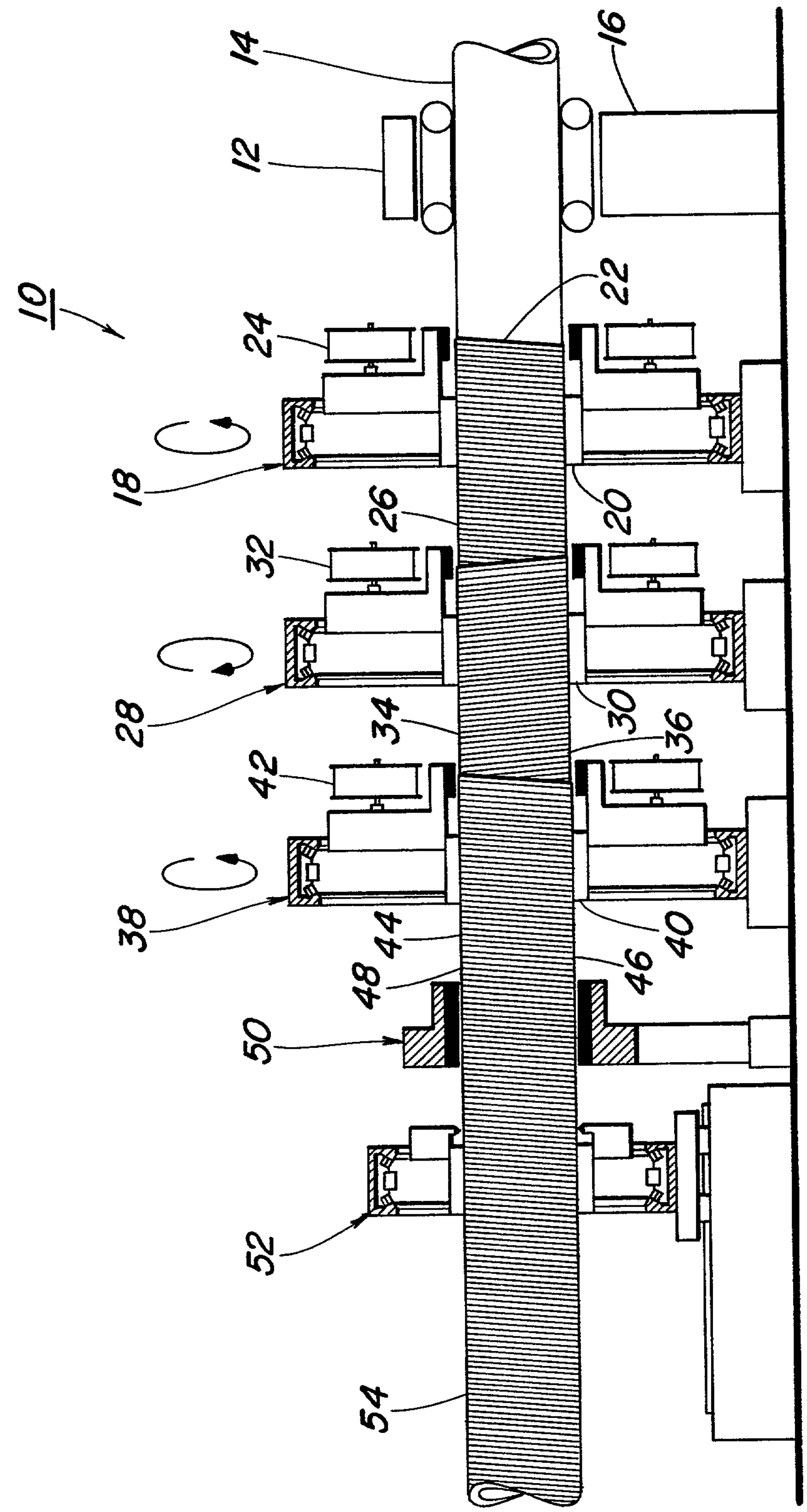

Fig. I

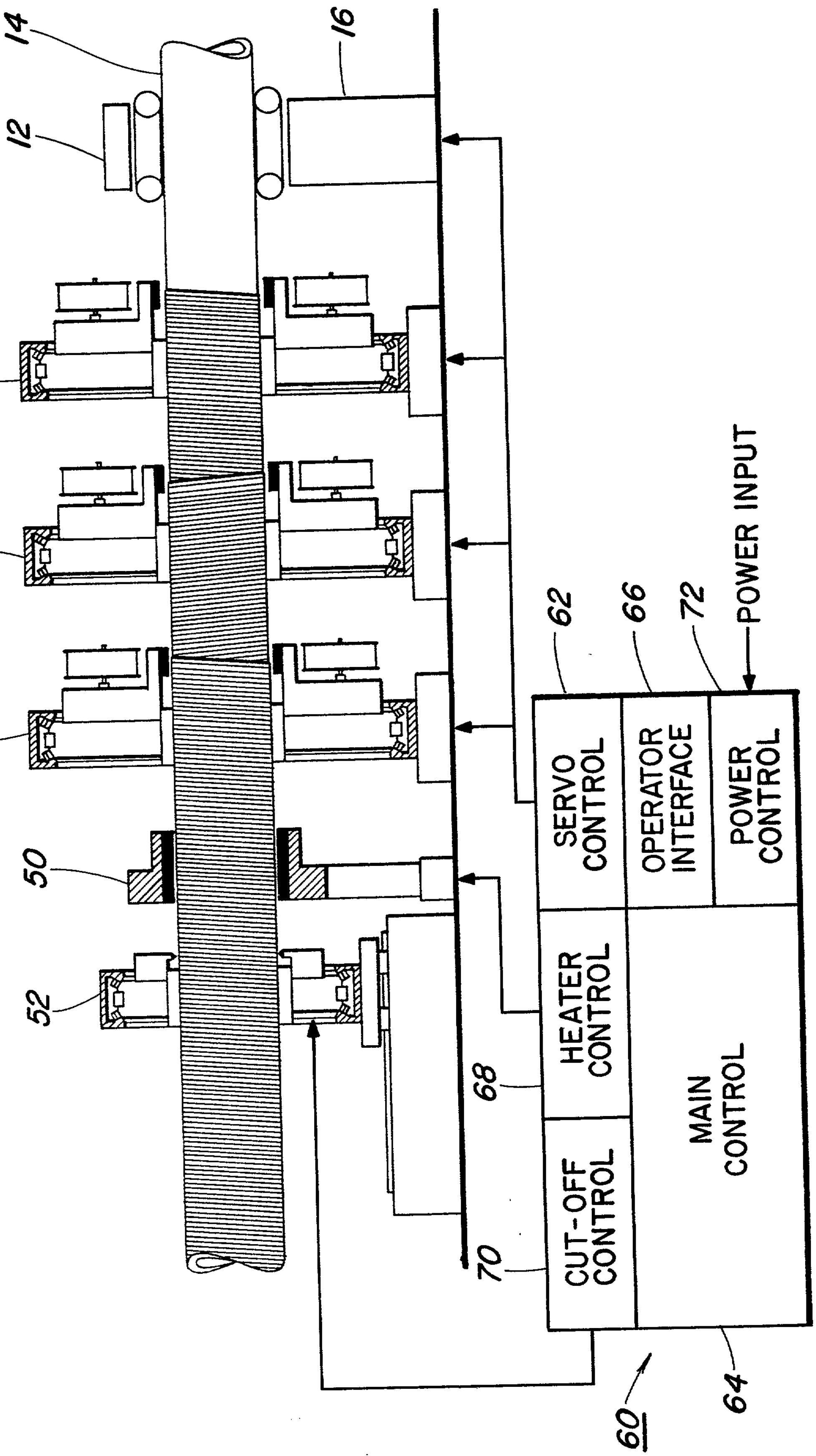
14
16
12
18
28
38
50
52
62
66
72
POWER INPUT
SERVO CONTROL
OPERATOR INTERFACE
POWER CONTROL
HEATER CONTROL
68
MAIN CONTROL
CUT-OFF CONTROL
70
64
60

Fig. 2

DECLARATION AND POWER OF ATTORNEY	ATTORNEY'S DOCKET NO. AD-2

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled REINFORCED THERMOPLASTIC PIPE MANUFACTURE __________, the specification of which

(check one)
- [X] is attached hereto.
- [ ] was filed on __________ as Application Serial No. __________ and was amended on __________. (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

Application Serial No.	Filing Date	Status (patented, pending, abandoned)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

John F. McDevitt, Reg. No. 19140,

SEND CORRESPONDENCE TO:

John F. McDevitt
2255 Par Lane #626
Willoughby Hills, Ohio 44094

DIRECT TELEPHONE CALLS TO: *(name and telephone number)*

(446) 585-0919

(continued)

DECLARATION AND POWER OF ATTORNEY - page 2

ATTORNEY'S DOCKET NO.
AD-2

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

SOLE OR FIRST INVENTOR:

Full name: David Edgar Hauber
First Name Middle Name Last Name

Signature: David Edgar Hauber Date: June 4, 1999
First Name Middle Name Last Name

Residence: Troy, New York
City and State

Citizenship: USA

Post Office Address: 111 Fales Court, Troy, New York 12180

SECOND JOINT INVENTOR, IF ANY:

Full Name: ______
First Name Middle Name Last Name

Signature: ______ Date: ______
First Name Middle Name Last Name

Residence: ______
City and State

Citizenship: ______

Post Office Address: ______

THIRD JOINT INVENTOR, IF ANY:

Full name: ______
First Name Middle Name Last Name

Signature: ______ Date: ______
First Name Middle Name Last Name

Residence: ______
City and State

Citizenship: ______

Post Office Address: ______